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A LASER BASED DISTORTION MEASURING SYSTEM(U) ADMIRALTY  
MARINE TECHNOLOGY ESTABLISHMENT DUNFERMLINE (SCOTLAND)  
J C BROWN AUG 82 AMTE(S)/TM2450 DRIC-BR-84191

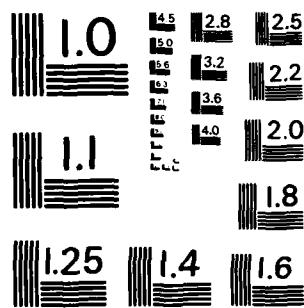
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REPORT AMTE(S) TM82450

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# ADMIRALTY MARINE TECHNOLOGY ESTABLISHMENT

A LASER BASED DISTORTION MEASURING SYSTEM (U)

J. C. Brown

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AUGUST, 1982

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AMTE(S) TM82450

A LASER BASED DISTORTION MEASURING SYSTEM (U)

BY

J C BROWN

Summary (U)

This report describes a recording system based on a low power laser and electro-optic detector developed for use in measuring distortions in structures.

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A LASER BASED DISTORTION MEASURING SYSTEM (U)INTRODUCTION

1. The collapse characteristics of structures under compressive loading are very dependent on deviations from perfect geometry. As computer based structural analysis has improved, increased account has been taken of the effect of initial imperfections and a need has developed for surveying structures to quantify the distortions which are present. The need for such data for ship structures has prompted the development of a method of measuring distortions which uses a laser beam to define a straight line from which measurements can be taken.

MANUAL RECORDING SYSTEM

2. In its simplest form this method was used in shipyards to measure deformations in large grillages prior to installation into the ships deck or bottom. To carry out these measurements, lines were marked out along and across the grillage. The laser was then set up on a tripod and adjusted to project its beam along the line of measurement a few cm above the grillage and approximately parallel to it.

3. A height gauge to which a white target with a black cross hair had been attached was used to measure the height from the grillage to the point at which the cross hair intercepted the centre of the laser beam. This could be repeated to an accuracy of better than 1 mm.

4. A set of measurements was obtained along and across the grillage. Using a rotating head on the tripod it was possible to sweep the laser in a level plane above the grillage to determine the relative heights of the intersections of the longitudinal and transverse measured axes to define the overall shape of the grillage.

AUTOMATIC RECORDING SYSTEM

5. In order to produce an accurate description of the deformations present in a grillage it is necessary to make a large number of measurements which would be very tedious and time consuming if conducted manually. It was therefore desirable to produce a means of making the measurements automatically.

6. The system devised is shown in Figure 1, where it is in use for measuring the out of flatness of an aluminium grillage prior to testing under compressive end load.

7. Figure 2 shows the equipment in schematic form. It consists of a position sensing electro-optic detector fitted to a vertical slide which is mounted on a carriage. The carriage runs on bearings on two parallel square tubes supported at one end on pivots from a box with the laser mounted on top and signal processing circuitry inside and at the other end in a frame with conical feet. Adjusting screws are provided for the conical feet at both ends to permit the system to be levelled prior to taking measurements. The carriage and the supports have been designed on kinematic principles.

8. One of the square tubes carries an insulated track into which 101 brass pins have been fitted at 2 cm pitch in a manner similar to a guitar finger board. The pins are inter-connected by 10 Ω resistors and have a stabilised 10 V DC supply connected across them. As the carriage is rolled along the track a spring loaded

contact picks up the voltage on each pin in sequence. This voltage triggers electronic sample and hold circuits in a data logger which records on magnetic tape cartridges the 'X' voltage from each pin and the corresponding 'Z' voltage from the electronic circuits associated with the electro-optic detector.

9. The 1.5 mW Helium Neon laser gives a 1 mm diameter beam with a divergence of 0.5 milliradians (mR). This means that the 'raw' beam diameter is just over 1 mm at the laser end of the track 'X' = 0 and just over 2 mm at 'X' = 2 metres. A X 5 collimating telescope is used to increase the beam diameter to 5 mm and reduce the beam divergence to 0.1 mR. A 5 mm diameter knife edge aperture fitted to the telescope removes unwanted side lobes.

10. The electro-optic detector is 100 mm long and 2.5 mm wide. To ensure that the laser beam falls centrally on the detector over the entire length of the track, a cylindrical lens is used to focus the beam onto the detector. The detector is positioned inside the focal plane of the lens so that the illuminated area is large enough to avoid exceeding the permissible power density of  $40 \text{ mW/cm}^2$  and damaging the detector.

11. The detector is of the lateral effect photodiode type and gives via signal conditioning circuits an output which is proportional to the position of the centroid of a spot of light on its sensitive area. There is provision in these circuits to compensate for the effect of background illumination provided it is fairly constant and not too high. The output is proportional to the brightness of the spot in addition to the position and this can give rise to errors if the power output of the laser is not stable. To overcome this problem an analog divider circuit is used to divide the position signal by the brightness signal.

12. All of this circuitry is incorporated in the laser stand together with a selector switch and digital voltmeter which is used for setting up and calibration. The circuits are shown in the form of a block diagram in Figure 3. Full details of the individual elements are given in the manufacturers data sheets which for completeness, and with their written permission, are reproduced in Appendix 1.

#### LASER SAFETY

13. There are many categories of lasers ranging from very low power laser diodes which are quite harmless to very high power cutting and pulse lasers which are very dangerous if not handled sensibly. The effects of laser radiation on the human body are discussed in reference (1)\* which outlines the hazards associated with different types of lasers and precautions for their safe usage. Further guidance is provided in references (2) and (3).

14. Apart from long term exposure of the skin to the direct beam from the laser, which would require deliberate action, the hazard from the lasers in use at AMTE is to the eye. Laser hazard warning notices, kept with the lasers, should be prominently displayed whenever the lasers are in use and all personnel in the area should be advised of the precautions necessary to avoid the hazard. These amount simply to not staring directly into the beam or its reflection. Scatter from diffuse surfaces is not hazardous.

15. Personnel using the laser are responsible for the safety of themselves and others and should handle the lasers in a manner which does not give rise to a hazard. This requires that the laser be switched off while preliminary alignment

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\*( ) References on Page 7

is carried out and ensuring that there is no risk of anyone looking directly into the beam or a strong reflection of it before switching on. The use of matt black paint on all metal parts is advisable and wherever possible protective screens and cordons should be used to restrict access to the immediate area from which the beam could be viewed.

16. Provided these simple commonsense precautions are taken the laser provides a very useful facility for making a variety of measurements safely.

#### PRACTICAL APPLICATION

17. Instructions for setting up and using the system are provided in Appendix 2. The equipment has been used to carry out surveys of the distortions present in steel and aluminium grillages prior to testing under load. Measurements have been made on the stiffener and on the plating sides of the grillages. Figure 4 shows a scan along a longitudinal stiffener of an aluminium grillage about 2 metres long. Figure 5 shows results from the plating on the stiffener side of the grillage between transverse and longitudinal stiffeners. The upper trace shows the shape of the individual panels between the transverse stiffeners while the lower one shows the overall shape of the grillage. These results were obtained by reading the magnetic tape cartridge from the data logger into a Tektronix 4052 graphic computer which was programmed to carry out the necessary computation and plot the results.

#### ACCURACY AND REPEATABILITY

18. During the development of the equipment the linearity of the detector system was checked at various distances, up to 2 metres from the laser, under subdued even lighting conditions and showed that over the central 60 mm it was linear within  $\pm 0.5$  mm and that over the entire 100 mm length the error was less than 1 mm.

19. Repeatability checks were carried out on an actual grillage under typical operating conditions where due regard had been paid to evenness of lighting. Three scans were made on each of several tracks on the grillage. The results of these tests showed maximum deviations from the average of the measured distortions to be less than  $\pm 0.5$  mm.

20. In order to achieve this accuracy it is necessary to ensure that the detector does not see uneven or fluctuating background illumination at a high level which will give rise to errors in both the sum and difference signals resulting in overall system errors. If the lighting conditions are not suitable these errors will show up in attempting to set the sum and difference zeros during calibration of the system.

#### CONCLUSIONS

21. The system described provides an efficient means of measuring and recording deviations from straightness or flatness of structures at 2 cm intervals in lengths of up to 2 metres, with an accuracy of about 0.5 mm under suitable lighting conditions. Larger structures may be surveyed by measuring individual sections up to 2 metres long and using the manual method to define the positions of the corners of these sections and permit the overall shape to be defined.

22. The magnetic tape cartridges produced by the data logger can be read into a mini computer to provide a graphic representation of the distortions present and to provide input data for structural analysis programs. The system may also be used for recording indentation damage such as in oil rig legs or submarine models and could be used over short arc lengths to provide data for determining deviations from round.

RECOMMENDATIONS FOR FUTURE WORK

23. The linearity of the detector is very good over its central region but beyond the central 75% significant errors can result. The non-linearity is however constant and could therefore be measured and stored as computer data to permit corrections to be made. A special calibration block of four 1 cm steps has been made for use with this system.

24. At present care is required in setting up the equipment to avoid possible errors resulting from uneven background lighting which may necessitate the use of screens to shade the detector under these conditions. It is intended to incorporate an optical filter in front of the cylindrical lens in the detector housing. This filter will have a narrow pass band centred on the laser frequency to permit attenuation of background illumination outwith the laser bandwidth and improve system performance.

25. An alternative system which could be built for use in particularly difficult lighting conditions consists of slotted disc rotating at a high speed, asynchronous with mains, which chops the laser light and a phase sensitive rectifier, reference (4), to process the resulting electronic signals.

ACKNOWLEDGEMENTS

26. The author wishes to acknowledge the contributions of Mr T Wilkins who carried out the mechanical construction of the system and Mr J M Penman and Mr D A Whyte for assistance in carrying out structural surveys using the system and writing the program for analysing the results using the Tektronix computer.

REFERENCES

1. Laser Systems - Code of Practice, 1969 Edition. M A A Wills, Chief Safety Officer, Ministry of Technology.
2. Guide on Protection of Personnel against Hazards from Laser Radiation. BS 4803 : 1972.
3. The Protection and Medical Surveillance of Personnel Exposed to Laser Radiation (U). DCI 56/1975.
4. Lock In Amplifier Uses Single I.C. David R Williams and William T Lum. Analogue Dialogue 8-1 (1974).

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LIST OF FIGURES

Figure 1 Automatic deflection measuring system in use

Figure 2 Automatic deflection measuring system schematic

Figure 3 Block diagram of electronic circuitry

Figure 4 Longitudinal stiffener out of straightness

Figure 5 Plating deformations

Figure A.1.4 Circuit connections, attenuators and adjustments

Figure A.2.1 Unit interconnections

Figure A.2.2 Setting 'X' position

Figure A.2.3 Layout of controls

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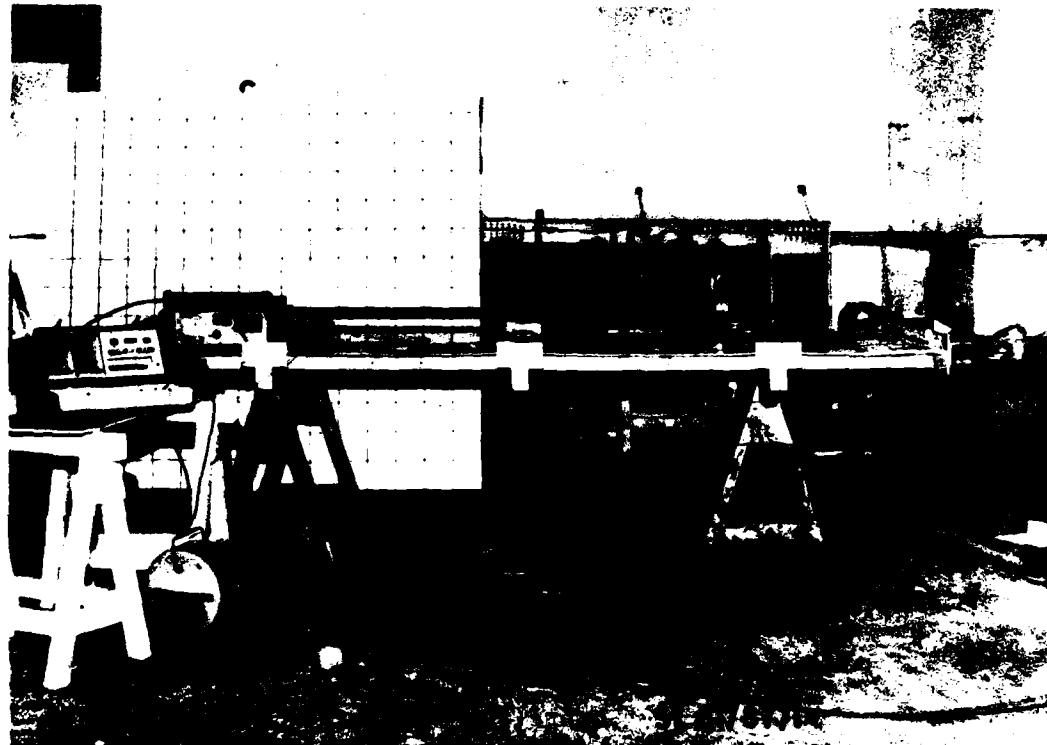


FIGURE 1

AMTE(S) TM82450

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SCHEMATIC LAYOUT OF LASER MEASURING SYSTEM

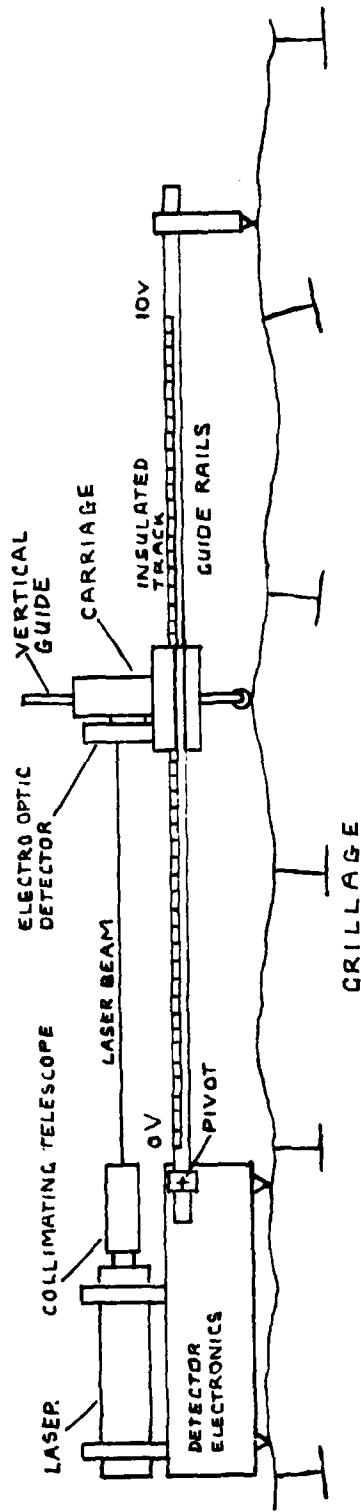


FIGURE 2

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BLOCK DIAGRAM OF DETECTOR ELECTRONICS

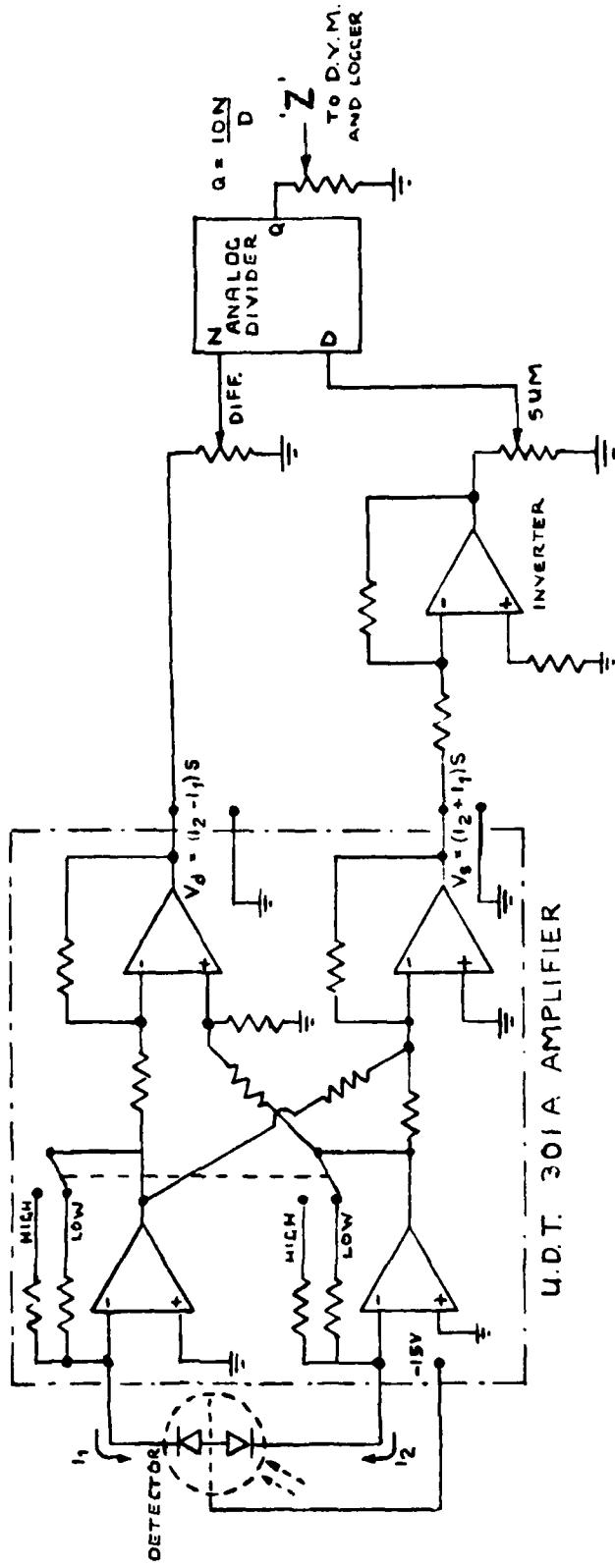


FIGURE 3

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GRILLAGE NO. 36 SCRN NO. 10  
TRACK NO. 3

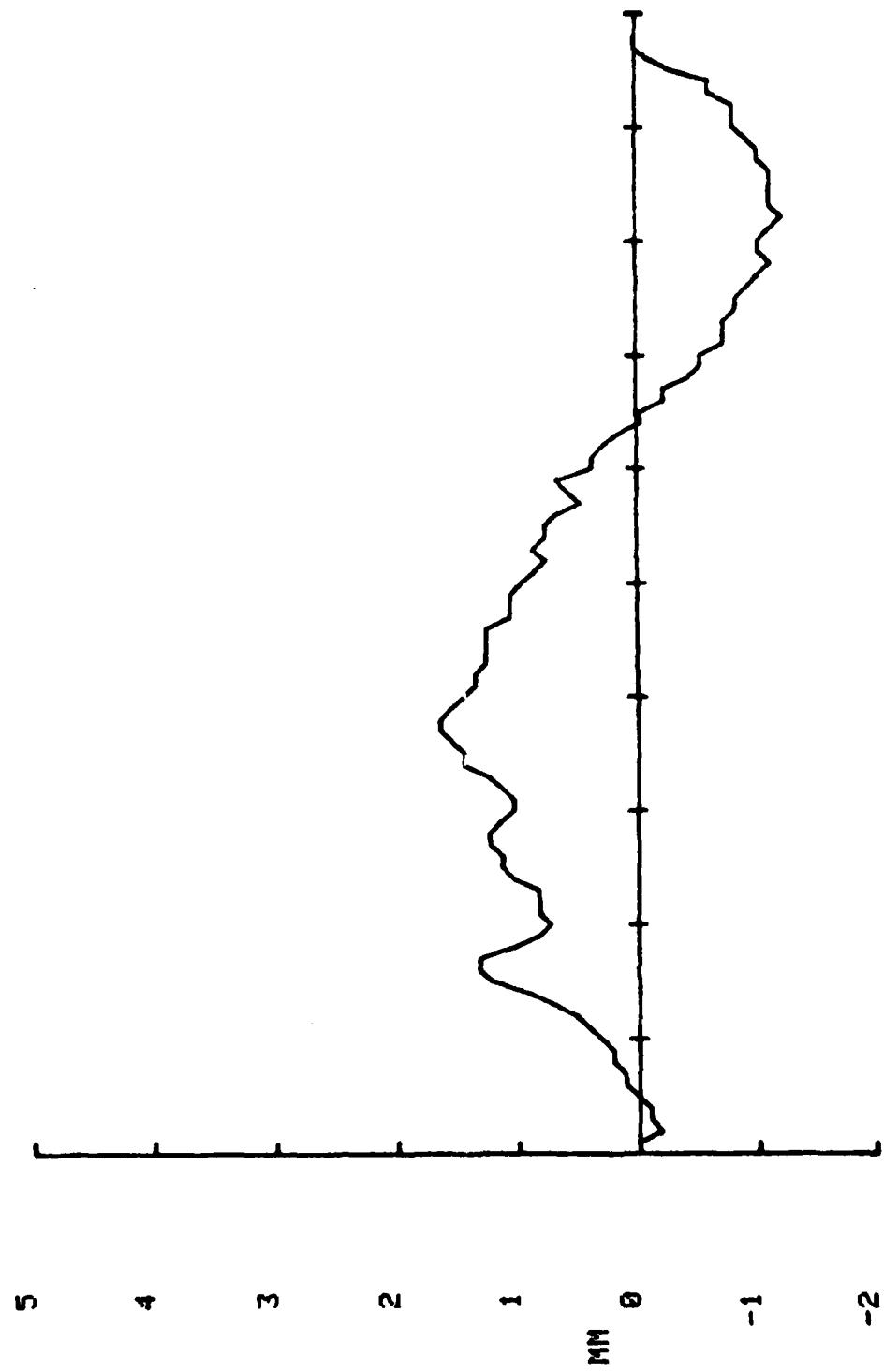


FIGURE 4

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GRILLAGE NO. 33 SCAN NO. 7  
TRACK NO. 34

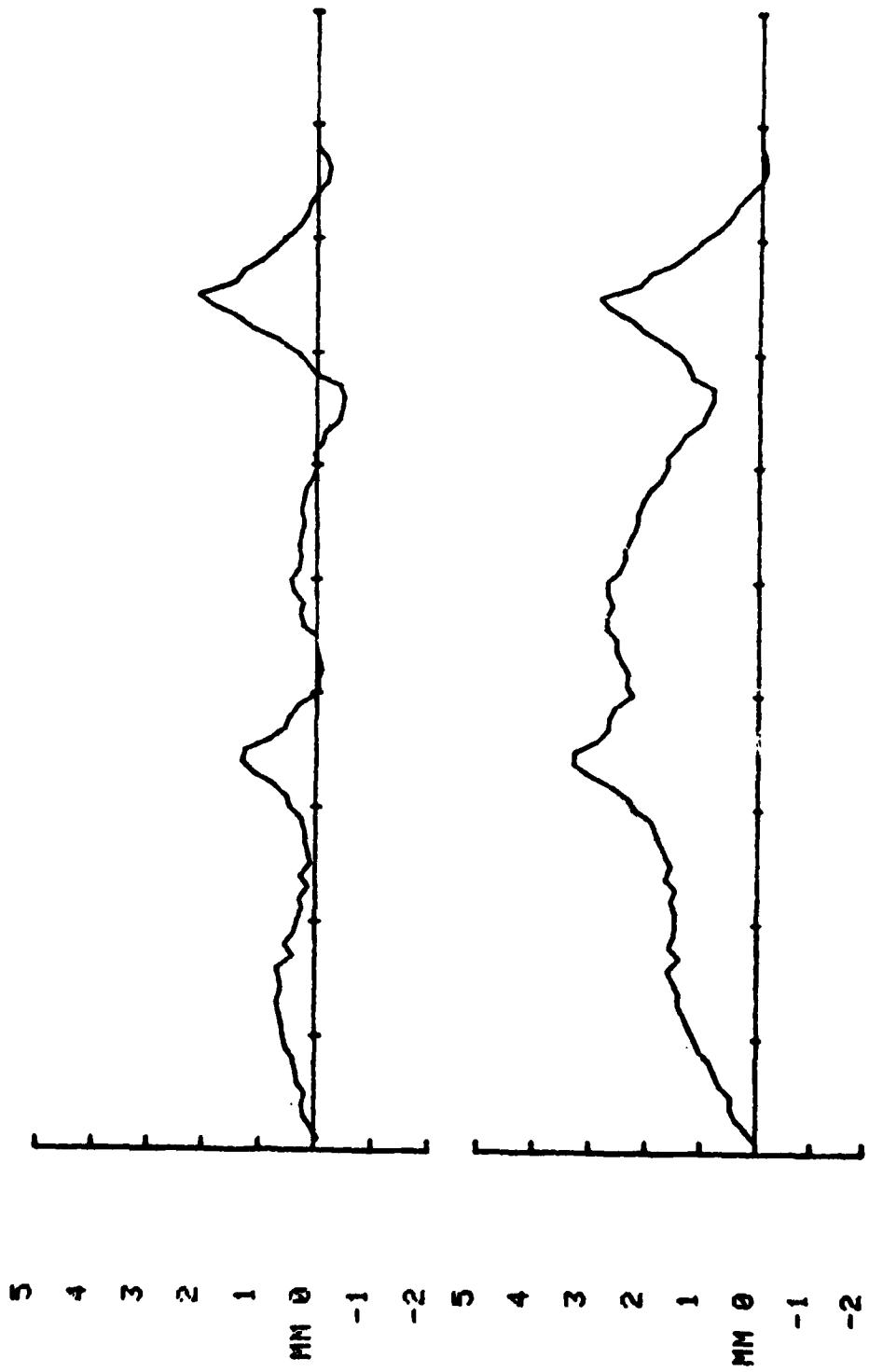


FIGURE 5

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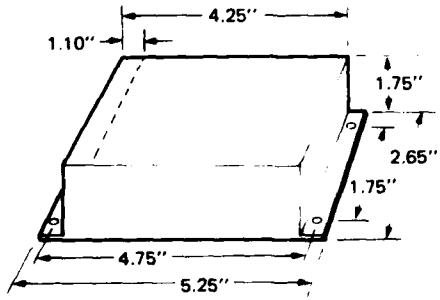
APPENDIX 1

1. UDT 301A Sum and Difference Amplifier. Manufacturers data sheet
2. Burr Brown 4291 Analog Divider. " " "
3. PCL DPM2 Digital Panel Meter. " " "
4. Circuit Connections, Attenuators and Adjustments.

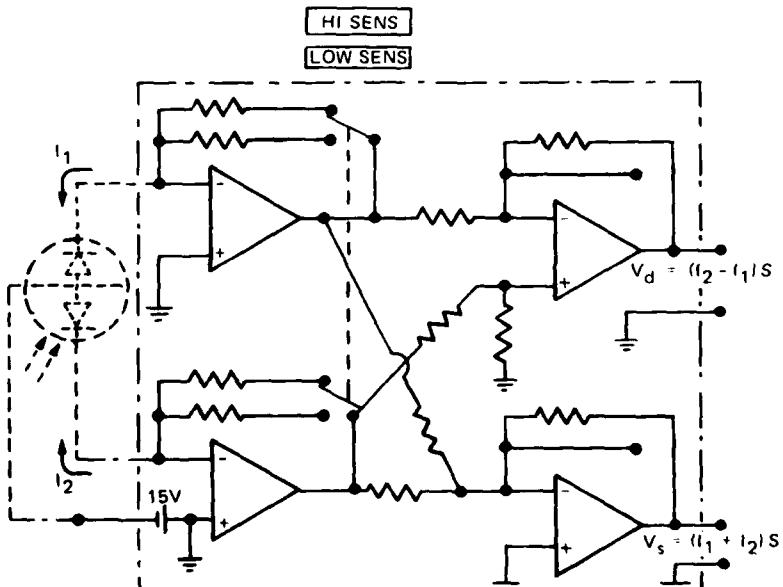
## ELECTRICAL SPECIFICATIONS

	Hi-Sensitivity	Low-Sensitivity
Transimpedance	$10^6$ volts/amp	$5 \times 10^4$ volts/amp
Input Current Range	$10^{-10}$ to $10^{-5}$ amps	$10^{-8}$ to $2 \times 10^{-4}$ amps
Frequency Response (to 3 db down)	DC to 5 kHz	DC to 5 kHz
Time Constant (63%)	$3 \times 10^{-5}$ seconds	$3 \times 10^{-5}$ seconds
Output Noise (full bandwidth, input open and shielded)	0.4 sum/0.3 diff. millivolt RMS	0.4 sum/0.3 diff. millivolt RMS
Volts output per watt input optical power at 800 nm	$4.0 \times 10^5$ volts/watt	$2.0 \times 10^4$ volts/watt
Output Impedance	75 sum/75 diff. ohms	
Output Current Available		10 millamps
Zero Offset Drift (after 5 minutes on)		10 millivolt/hour
Output Voltage Range		$\pm 10$ volts
Temperature Range		0 to 40° C (32 to 105° F)
Power		Two 12.6-volt mercury batteries (Eveready E-289 or Mallory RM 289)
Battery Life		25 hours

## MECHANICAL SPECIFICATIONS



## SCHEMATIC DIAGRAM



S-011-1276



**UNITED DETECTOR TECHNOLOGY, INC.**  
2644 30TH STREET, SANTA MONICA, CA 90405 ■ TELEPHONE (213) 396-3175 ■ TELEX 65-2413

UNLIMITED

301A SUM AND  
DIFFERENCE AMPLIFIER



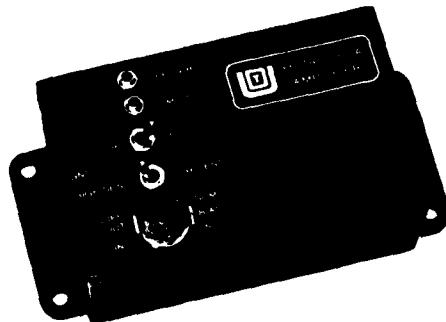
# UNITED DETECTOR TECHNOLOGY, INC.

The UDT 301A AMPLIFIER is designed for use with continuous position sensing photodiodes. The amplifier provides two voltage outputs, corresponding to the sum and difference of two input currents, such as those from a two quadrant position sensitive photodiode.

The difference output voltage is proportional to both spot intensity and light spot position. Sum output is proportional only to light spot intensity. Dividing the difference output by the sum output provides a spot position signal independent of intensity (divider circuit not included).

#### SUGGESTED APPLICATIONS

Displacement Monitors  
Angle Monitors  
Optical Comparators



#### COMPATIBLE UDT DETECTORS

PIN-LSC/4	PIN-Spot/2D*
PIN-SC/10	PIN-Spot/4D*
PIN-SC/25	PIN-Spot/8D*
PIN-SC/50	

Note: Two 301A amplifiers are required for SC and Spot series detectors.

\*Amplifier bias polarity must be changed.

#### OPERATION

Two input leads and a bias voltage are connected to the detector. The 301A applies a negative 12-volt bias to the sensor. CARE MUST BE TAKEN THAT THE PHOTODIODE ANODE (-) IS CONNECTED TO CENTER PIN MARKED "GND" ON INPUT/OUTPUT CONNECTOR. The sum and difference output leads can be connected to an oscilloscope, dc meter, or ac meter.

When using any of UDT's SC and LSC series detectors, (PIN-SC/10, PIN-SC/25, PIN-SC/50 or PIN-LSC/4), the center pin on the photodiode must be connected to the center pin (marked GND) on the 301A. For connection to UDT's SPOT series photodiodes (PIN-Spot/2D, PIN-Spot/4D, PIN-Spot/8D) the 301A must be factory modified to provide a positive twelve-volt or zero bias, depending on desired application.

#### THE 301A IS A CURRENT TO VOLTAGE CONVERTER. TRANSFER FUNCTIONS FOR THE SUM AND DIFFERENCE OUTPUTS ARE:

$$\text{Hi-Sensitivity: } V_{\text{out}} \text{ (volts)} = I_{\text{sum or diff.}} \text{ (amps)} \times 10^6 \text{ (volts/amp)}$$

$$\text{Low-Sensitivity: } V_{\text{out}} \text{ (volts)} = I_{\text{sum or diff.}} \text{ (amps)} \times 10^4 \text{ (volts/amp)}$$

Output sum voltage is related to total light on the position photodiode by the expression:

$$V_{\text{out}} = L_{\text{light}} \times R_{\text{photodiode}} \times S_{\text{amplifier}}$$

watts      responsivity,      transimpedance,  
              amp/watt      photodiode      amplifier

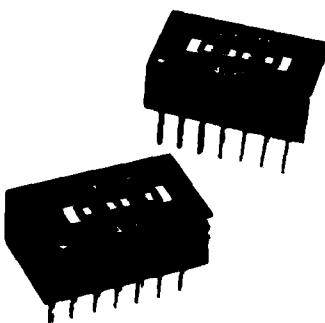
Output difference motion is related to the light spot motion on the detector surface by the expression:

$$V_{\text{diff. out}} = L_{\text{light}} \times D_{\text{max}} \times R_{\text{photodiode}} \times S_{\text{amplifier}}$$

D = distance from one side of detector

D<sub>max</sub> = detector length or diameter

UNLIMITED



4291

## ANALOG DIVIDER

### FEATURES

- HIGH ACCURACY  
0.25% max for  $D > 100mV$
- EASY TO USE  
No external components required
- WIDE DYNAMIC RANGE  
 $10mV < D < 10V$
- SMALL SIZE  
14 pin dual-in-line package

### DESCRIPTION

The 4291 hybrid IC divider offers high accuracy over a 100 to 1 dynamic range with no external components required, and the specified accuracy can be achieved with denominator voltages as low as 100mV.

The unique circuit approach produces a two-quadrant divider with performance that exceeds that of conventional multiplier/dividers. With the addition of several external resistors to null the offset and gain errors, an accuracy of 0.1% can be achieved with denominator voltages down to 10mV.

Manufacturers of industrial control systems and analytical instruments will find the 4291 to be a low cost, accurate solution to many of their signal processing problems.

## DEFINITION OF SPECIFICATIONS

**ACCURACY:** The accuracy of the divider is specified as a percent of full scale (10V) and is derived from the total error specification.

**TOTAL ERROR:** The total error specification means that at  $+25^{\circ}\text{C}$  with  $\pm 15\text{V}$  supplies, the divider output will always be within the specified percentage (of full scale) of the ideal transfer function,  $E_O = 10^N$  for  $D$  greater than the specified voltages and for  $N < D$ .

Beware of analog dividers which only specify total error for  $D = 10\text{V}$  or do not specify error drift for  $D < 10\text{V}$ . In some cases the errors for  $D = 0.1\text{V}$  may be 100 times the error at  $D = 10\text{V}$ .

**SCALE FACTOR ERROR:** With  $N = D = 10\text{V}$  and the output offset zeroed, scale factor error represents the difference between the actual voltage and 10.000V.

**NON-LINEARITY:** With  $D = 10\text{V}$ , non-linearity is defined as the departure of  $E_O$  from a straight line when  $N$  varies between 5 mV and 10V. Non-linearity is best observed on an oscilloscope or x-y plotter. (See Figure 6.)

**DYNAMIC PERFORMANCE:** The frequency response specifications are generally self-explanatory. Small signal -3dB bandwidth is typically 400 kHz.

**OVERLOAD RECOVERY:** Overload recovery is the time required for  $E_O$  to settle within 50 mV of final value if  $N$  or  $D$  are first driven negative or if the output saturates ( $N > D$ ). In contrast, overload recovery may require as much as 1 sec. if a "chopper" (modulation) type multiplier is used for division.

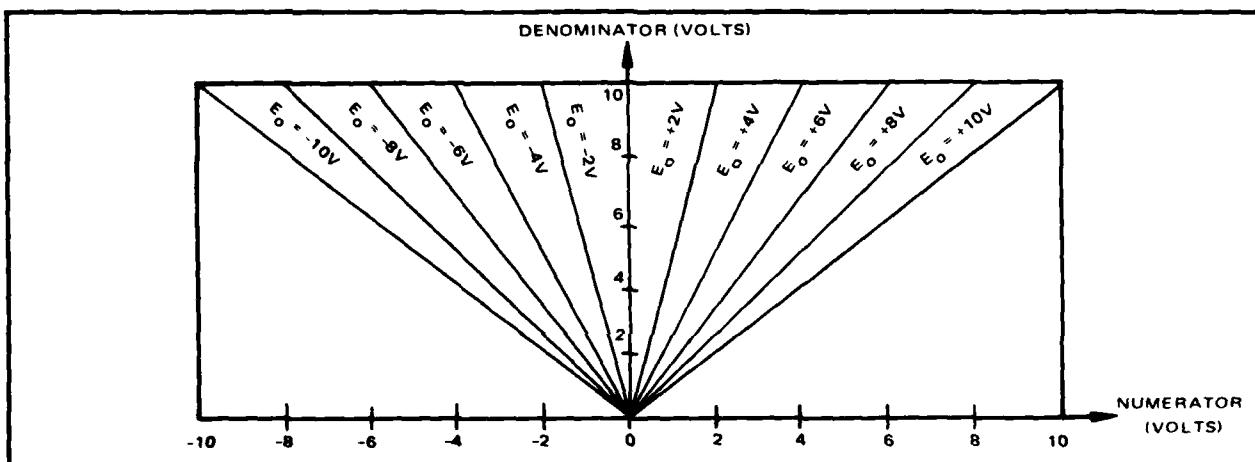


FIGURE 1. Operating Region Curve

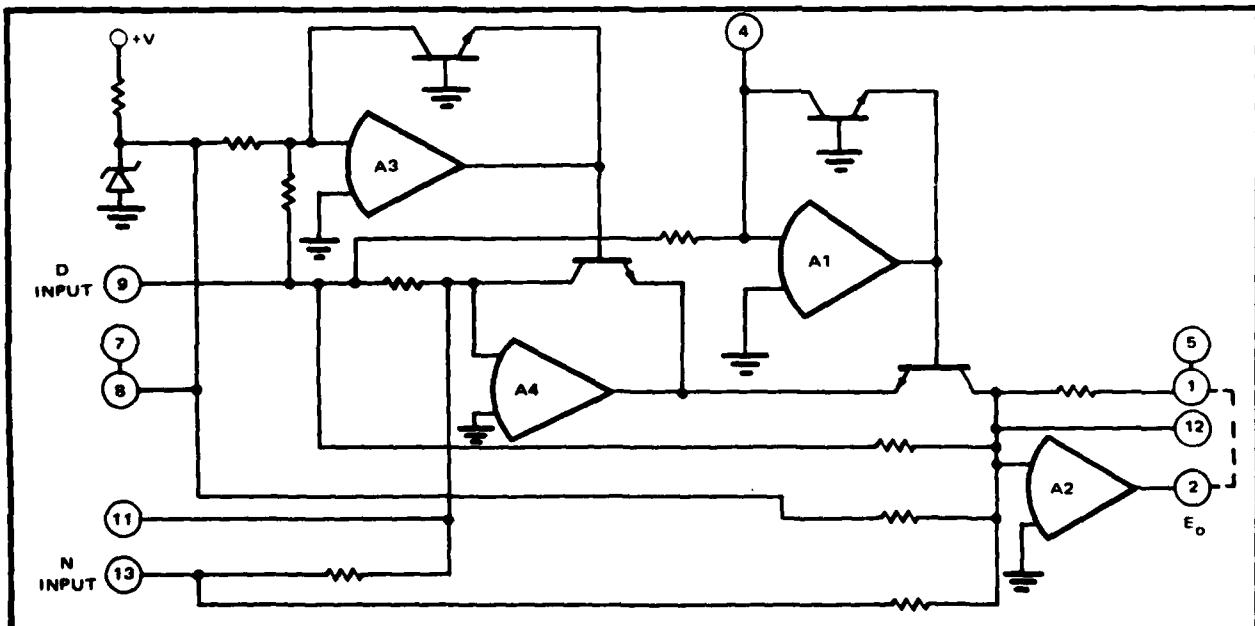


FIGURE 2. Simplified Schematic.

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**SPECIFICATIONS**

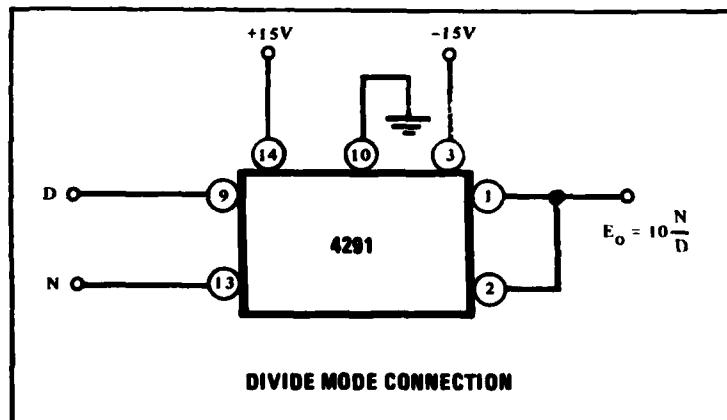
Typical performance at +25°C with rated power supplies unless otherwise noted.

Percent specifications refer to % of full scale (10V)

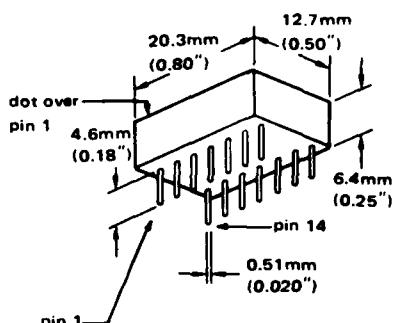
**ELECTRICAL**

MODEL	4291 H	4291 J	4291 K
Transfer Function		$E_O = 10 \frac{N}{D}$	
<b>ACCURACY</b>			
Total Error No external trims, (max). D > 100 mV With external trims, D > 10 mV	1% 0.25%	0.5% 0.1%	0.25% 0.1%
Error vs. Temperature		0.03%/°C	
Error vs. Supply		0.15%/%	
<b>AC PERFORMANCE, D = +10V</b>			
Small signal, -3dB	400 kHz		
Full Power Response	20 kHz		
0.5% amplitude error	15 kHz		
0.5% vector error	600 Hz		
Slew rate	1.25 V/usec		
<b>INPUT CHARACTERISTICS</b>			
Rated Input voltages	$-10V \leq N \leq +10V$ $+10mV \leq D \leq +10V$ and $ N  \leq D$		
Maximum safe level, N,D	$\pm$ supply		
Input Impedance	$25 k\Omega$		
<b>OUTPUT CHARACTERISTICS</b>			
Rated output voltage, min	$\pm 10V$		
Rated output current, min	$\pm 5mA$		
Output Impedance	$0.1\Omega$		
Output Noise, 10 Hz to 10 kHz	See Figure 4		
<b>TEMPERATURE RANGE</b>			
Specified Performance	$0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$		
Operating	$-25^{\circ}\text{C}$ to $+85^{\circ}\text{C}$		
Storage	$-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$		
<b>POWER SUPPLY REQUIREMENTS</b>			
Rated supply	$\pm 15VDC$		
Operating range	$\pm 14$ to $\pm 16VDC$		
Quiescent current	$\pm 15mA$ , $-8.5mA$		

Prices and specifications subject to change without notice.



**MECHANICAL**



Row Spacing: 7.6mm (0.300")  
Weight: 3.4 grams (0.12 oz.)  
Connector: 14 pin DIP

0145MC

Pin material and plating composition conform to Method 208 (solderability) of Mil-Std 202.

**PIN CONNECTIONS**

○ 14	1 ○
○ 13	2 ○
○ 12	3 ○
○ 11	4 ○
○ 10	5 ○
○ 9	6 ○
○ 8	7 ○

(BOTTOM VIEW)

1 Gain Error Adjust	8 Reference Voltage
2 Output	9 D Input
3 -15VDC	10 Common
4 D Input Offset Adj.	11 N Input
5 Internally connected to Pin 1	Offset Adjust
6 Internally connected to Pin 14	12 Output
7 Internally connected to Pin 8	Offset Adjust
	13 N Input
	14 +15VDC

## TYPICAL PERFORMANCE CURVES

Typical Performance ( $\approx 25^\circ\text{C}$  and Rated Supplies)

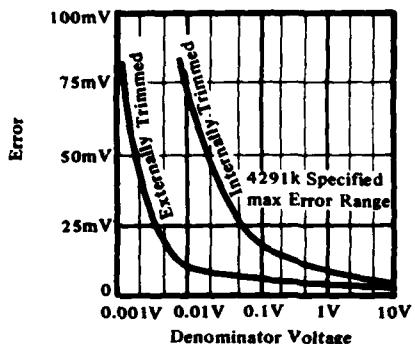


FIGURE 3. Output Error vs. Denominator Voltage

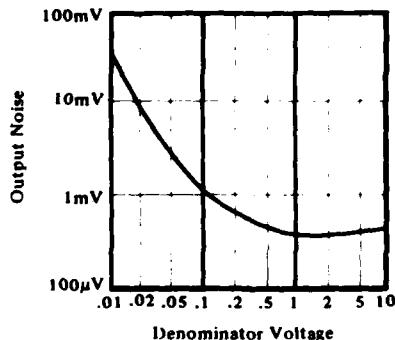


FIGURE 4. Output Noise vs. Denominator Voltage

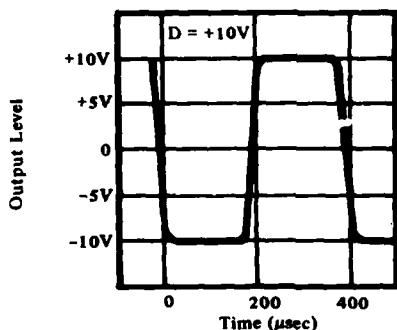


FIGURE 5. Step Response

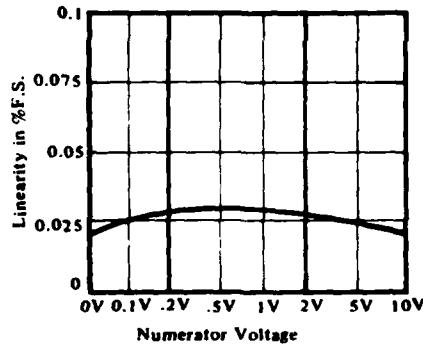
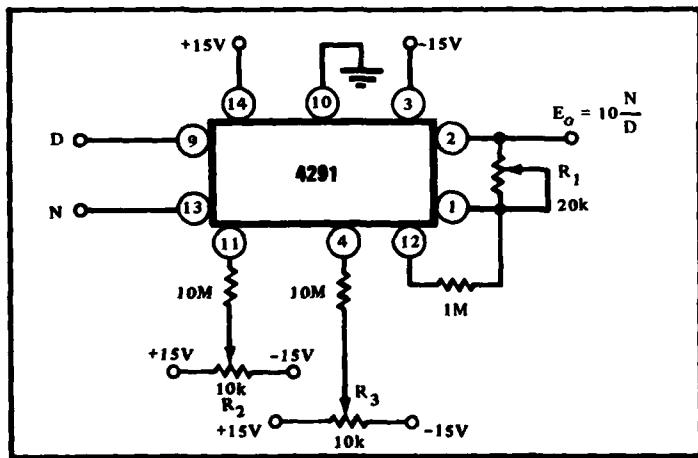


FIGURE 6. Linearity vs. Numerator Voltage

## OPTIONAL ADJUSTMENT PROCEDURES



By following this adjustment procedure, the accuracy and dynamic range of the 4291 can be improved, as indicated in the Electrical Specification table. Note that the numerator gain is 1,000 when  $D = 10 \text{ mV}$ , so the accuracy drift will normally be somewhat worse than  $0.03\%/^\circ\text{C}$  which applies for  $D \geq 100 \text{ mV}$ .

1. With  $N = D \approx 10,000 \text{ V} \pm 1 \text{ mV}$ , adjust  $R_1$  such that  $E_o = +10,000 \text{ V} \pm 1 \text{ mV}$ .
2. Set  $D$  at the minimum expected denominator voltage. With  $N = -D$  adjust  $R_2$  such that  $E_o = -10,000 \text{ V}$ .
3. Set  $D$  at the minimum expected denominator voltage. With  $N = D$  adjust  $R_3$  such that  $E_o = +10,000 \text{ V}$ .
4. Repeat steps 2 and 3 as required.



DPM1  
DPM2  
3 1/2 DIGIT LCD PANEL METERS

DPM 1 and 2 are modular digital panel meters with character heights of 0.7" and 0.5" respectively. The design includes a bezel and clear filter which allows easy panel mounting.

The Meters use the dual slope integration technique and offer differential input, auto polarity, auto zero and overvoltage indication (by blanking the least significant three digits.)

The nominal supply voltage is 9V, and the supply current typically 1mA.

SPECIFICATION

Maximum ratings

Max. supply voltage + V to -V	15V
Max. supply current	2mA
Max. input voltage	+V to -V
Storage temperature range	-20°C to +70°C
Working temperature range	0 to +50°C

Performance

FSD	199.9 mV (Suffix A), 1.999V (suffix B)
Accuracy	+ 0.1% + 1 count
Resolution	100µV (199.9mV FSD), 1mV (1.999 V)
Temperature coefficient	+ 330ppm/°C max.
Temperature drift of zero	+ 1 count over range 0 to + 50°C
Input impedance	100M Ohm. min.
Input leakage current	10pA max.

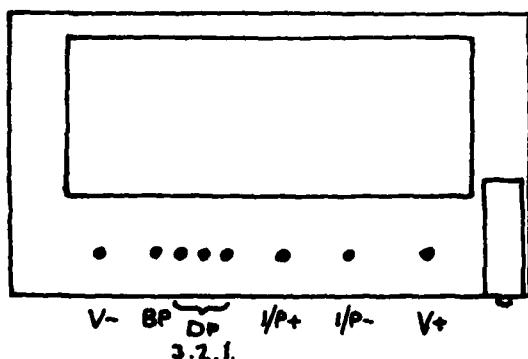
Display

Polarity	shown by minus sign
Over-range	shown by 3 L.S.D.'s blanked
Decimal point	externally driven

Dimensions (mm)

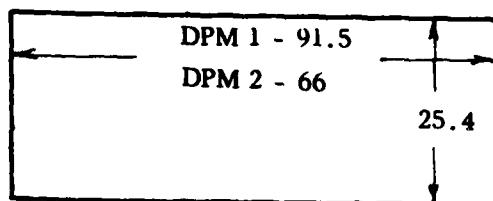
Bezel size	94 x 38 (DPM 1), 68 x 38 (DPM 2)
Depth behind panel	18 excluding bezel studs
Max. Panel thickness	7

### Connections



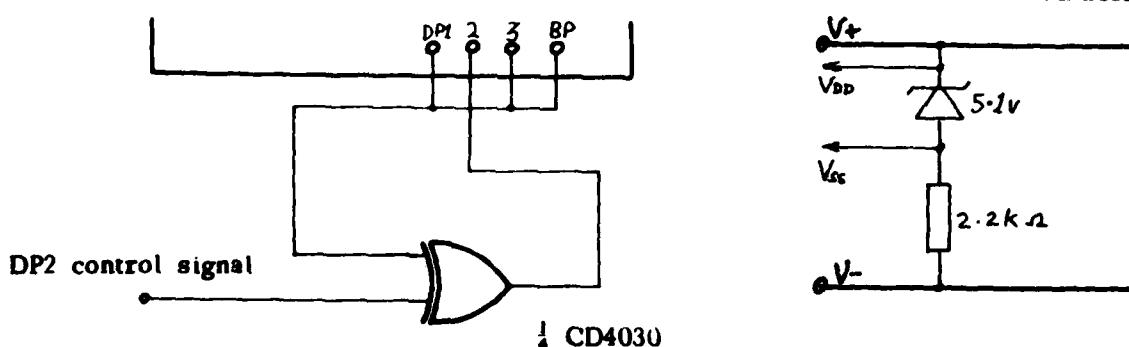
NOTE: The supply should always be electrically isolated from the voltage being measured.

### Panel Cutout (mm)



### Decimal Points

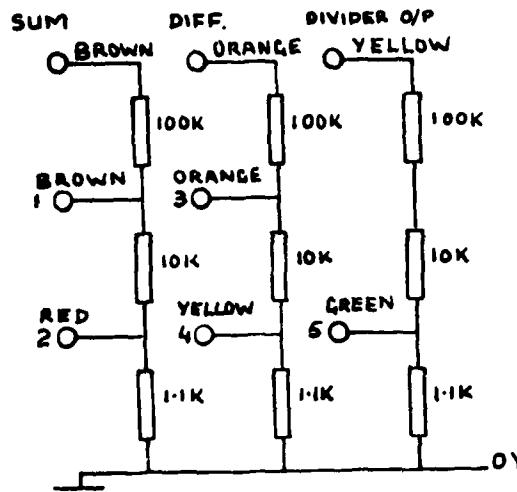
The decimal point and backplane connections are brought out to terminals so that the user can select the required DP, or provide auto ranging. Unused DP connections should be tied to B.P. The required DP should be connected to the circuit shown below:-



Connecting the DP segment to ground, or a d.c. source will shorten the L.C.D. life and is not recommended.

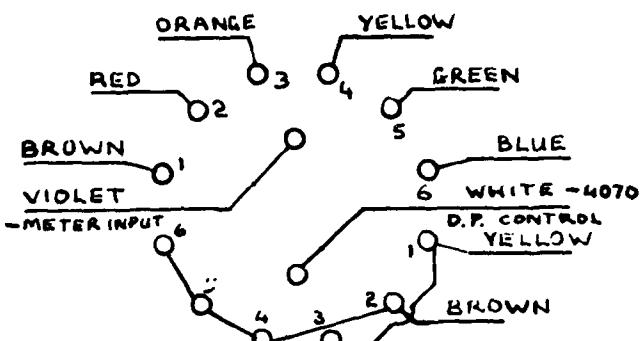
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### ATTENUATOR



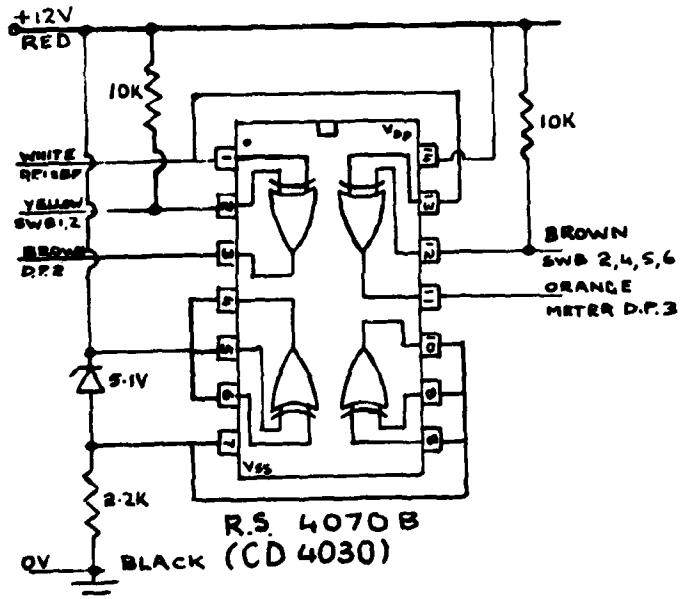
### SELECTOR SWITCH

#### VOLTAGE READING SW.A

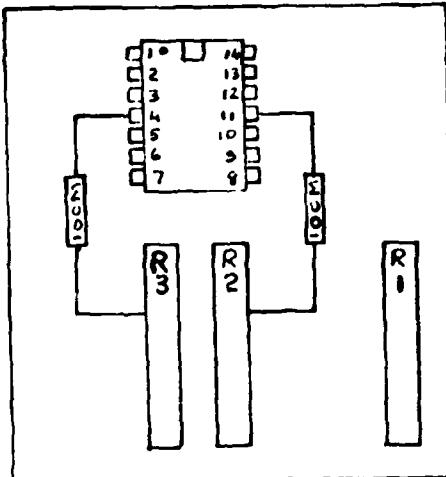


#### DECIMAL POINT SW.B

### VOLT METER D.P. CONTROL



### 4291 ANALOG DIVIDER



ADJUSTMENTS  
SEE DATA SHEET

FIGURE A 1.1

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AMTE(S)TM82450

APPENDIX 2Operating Instructions

1. Connect units as shown in Figure A.2.1.
2. Position and level laser stand and end support so that roller follows the required track on the structure and is correctly positioned in the 'X' direction. See 'Setting Alignment' and Figure A.2.2.
3. Set calibration as described in the calibration section below.
4. Record required measurements as described in the recording section below.  
Note with logger set to RECORD readings are displayed but not recorded unless SCAN is also set.
5. When measurements complete. Press Unload. Remove cartridge and set it to SAFE to avoid accidental erasure.

Calibration

Adjust detector vertically on guide to centre laser spot. Refer to Figure A.2.3 and check switch positions as follows.

1. SUM ZERO - SET TO ZERO WITH LASER OFF.
2. SUM FULL SCALE - WITH LASER ON AND DETECTOR CLOSE TO LASER SET TO MAXIMUM USING SUM O/P. REDUCE TO NEAREST CONVENIENT WHOLE NUMBER eg 10 V or 8 V.
3. DIFFERENCE ZERO - SET TO ZERO.
4. DIFFERENCE FULL SCALE - PLACE 2.5 cm CALIBRATION BLOCK UNDER ROLLER. USING DIFFERENCE O/P ADJUST TO READ 2.5 V OR JUST OVER.
5. DIVIDER O/P. 'Z' =  $10 \times$  DIFFERENCE O/P  $\pm$  sum op. SET TO 2.50 V. IF THIS IS NOT POSSIBLE REDUCE SUM O/P OR INCREASE DIFFERENCE O/P AS NECESSARY.
6. 'X' O/P. CHECK BY MOVING CARRIAGE THAT THIS READS CORRECTLY.

Setting Alignment

Having set up the system so that the roller supporting the detector follows the correct track, make small lateral adjustments, by sliding the back foot of the laser stand, to centre the laser beam in the detector with the carriage at the far end of the track. When the laser is off centre, its reflection from the detector causes a double spot on the face of the cylindrical lens. When the laser is central only one spot is visible.

Adjust the back foot of the laser stand vertically so that the 'Z' readings are more or less equal with the carriage at the extreme ends of the track. In a typical application the 'X' position is set so that the guide rod carrying the detector housing is touching the flange of a T-bar with the spring loaded 'X' contact on one of the brass pins. The dimension ① and the first 'X' reading corresponding to dimension ② are noted permitting the measured profile to be correctly related to the stiffener centre when the results are analysed. For

measurements on the plating side it is only necessary to centre the roller on the starting point for a suitable 'X' reading, normally 0000.

#### Recording

The following is a typical procedure for carrying out a survey.

Set up grillage stiffener side up.

With the data logger set on 'record' set up header data using thumbwheel switches and enter using 'single shot' button on logger.

Move carriage to a position close to the centre of the track and set 'Scan'.

1. Record ten 'ZEROS' by rolling the carriage to contact the nearest 'X' displacement pin ten times. Put the 2.5 cm calibration block under the roller of the detector vertical guide and record ten 'CALS'. Remove the calibration block and record ten 'ZEROS'. Press 'STOP'.
2. Return carriage to start of track. Set 'SCAN'. Roll the carriage slowly along the track to the end. Press Stop. Repeat (2) for a total of three times.

Repeat 1 and 2 for all longitudinals and panel centre lines.

Turn grillage over and repeat 1 and 2 for all tracks on plating side.

Set up trestles either side of grillage to support recording system. Repeat 1 and 2 for all transverse tracks eg centreline and quarter points of each panel.

#### Maintenance

At regular intervals of 12 months or less the accuracy of the digital panel meter and the analog divider circuit should be checked and if necessary adjusted in accordance with the manufacturers data sheets reproduced in Appendix 1.

All bearings should be lubricated occasionally with light oil and the brass pins of the 'X' displacement track should be kept clean.

The laser and the detector are delicate precision instruments and should be kept clean and handled with care.

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### UNIT INTERCONNECTIONS

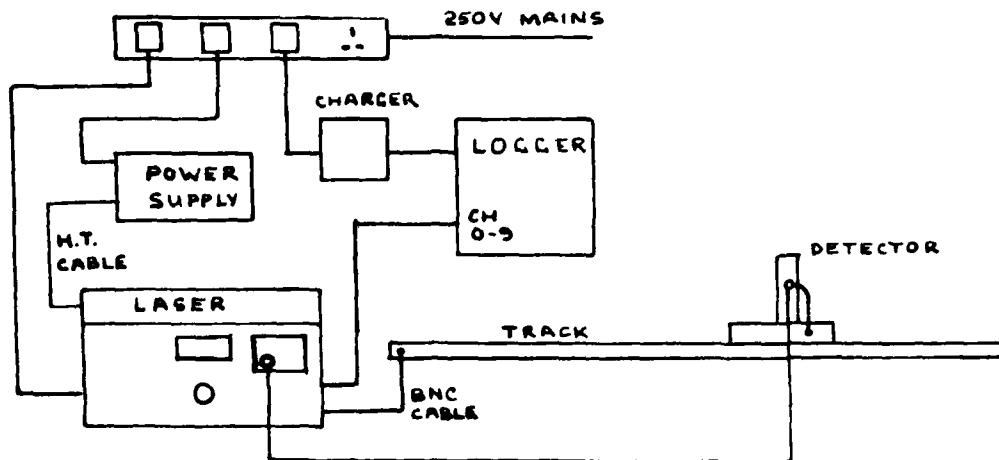


FIGURE A 2.1  
SETTING 'X' POSITION

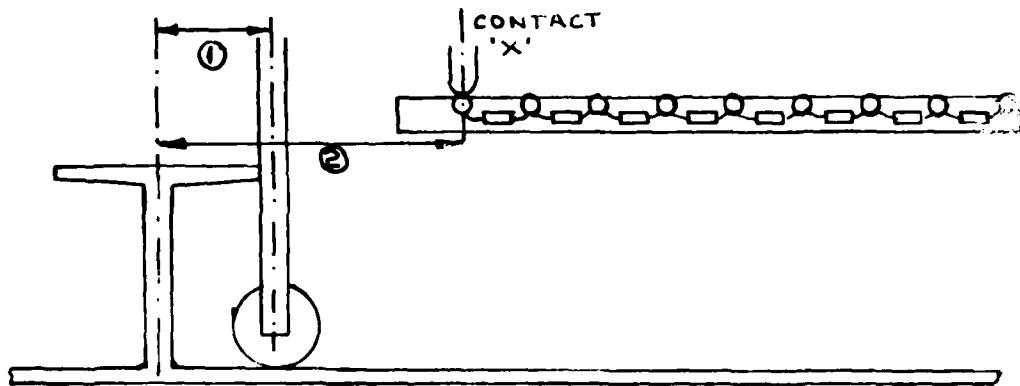
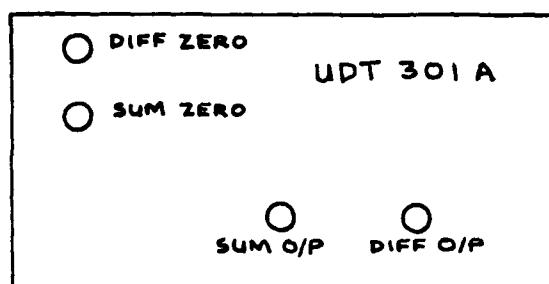
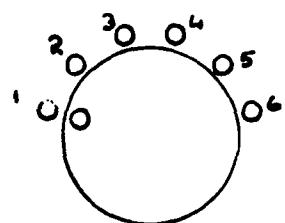


FIGURE A 2.2  
LAYOUT OF CONTROLS

- 1 SUM ZERO
- 2 SUM FULL SCALE
- 3 DIFF ZERO
- 4 DIFF FULL SCALE
- 5 DIVIDER O/P 'Z'
- 6 'X' POSITION

SELECTOR  
SWITCH



DIVIDER O/P  
O

FIGURE A 2.3

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AMTE(S)TM82450

## DOCUMENT CONTROL SHEET

(Notes on completion overleaf)

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1. DRIC Reference (if known)	2. Originator's Reference  AMTE(S) TM82450	3. Agency Reference	4. Report Security Classification  <b>UNLIMITED</b>
5. Originator's Code (if known)	6. Originator (Corporate Author) Name and Location  Admiralty Marine Technology Establishment (Dunfermline) St Leonard's Hill, Dunfermline, Fife, KY11 5PW		
5a. Sponsoring Agency's Code (if known)	6a. Sponsoring Agency (Contract Authority) Name and Location		
7. Title  LASER BASED DISTORTION MEASURING SYSTEM (U)			
7a. Title in Foreign Language (in the case of translations)			
7b. Presented at (for conference papers). Title, place and date of conference			
8. Author 1, Surname, initials  Brown, J C	9a. Author 2	9b. Authors 3, 4...  .....	10. Date      pp      ref  08.1982      30      4
11. Contract Number	12. Period	13. Project	14. Other References
15. Distribution statement  Distribution controlled by MOD Technical Policy Authority, Research Area Leader 1, CS AMTE (Dunfermline)			
Descriptors (or keywords)  Distortion measurement; Optical metrology; Lasers; Electro-optics			
Summary (U)  This report describes a recording system based on a low power laser and electro-optic detector developed for use in measuring distortions in structures.			

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- 9a. Author 2: Enter the name of the second author, followed by his initials.
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<b>AMTE(S) TM82450 A LASER BASED DISTORTION MEASURING SYSTEM (U)</b>	<u>SUBJECT INDEX</u>  This report describes a recording system based on a low power laser and electro-optic detector developed for use in measuring distortions in structures.	<b>AMTE(S) TM82450 A LASER BASED DISTORTION MEASURING SYSTEM (U)</b>	<u>SUBJECT INDEX</u>  This report describes a recording system based on a low power laser and electro-optic detector developed for use in measuring distortions in structures.
<b>AMTE(S) TM82450 A LASER BASED DISTORTION MEASURING SYSTEM (U)</b>	<u>SUBJECT INDEX</u>  Distortion measurement Optical metrology Lasers Electro-optics	<b>AMTE(S) TM82450 A LASER BASED DISTORTION MEASURING SYSTEM (U)</b>	<u>SUBJECT INDEX</u>  Distortion measurement Optical metrology Lasers Electro-optics

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